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Phosphorus fractions in subtropical soils depending on land use

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ABSTRACT

Land-use change from forest to agriculture, which is driven by the demands of sustaining the growing global population, affects nutrient dynamics and availability in soil. Although phosphorus (P) is one of the main limiting nutrients in agricultural production, little is known about the influence of soil microorganisms on the dynamics of P cycling in subtropical land use systems. The objective was to assess the impacts of land use (organic farming, conventional farming and forest) on forms and distribution of P in soil.

After conversion of forest, the P stock significantly increased by 373% and 170% in soil under organic farming at 0–10 and 10–20 cm depth, respectively. In conventional farming, the P stock increased by 64% and 36% at 0–10 cm and 10–20 cm depth, respectively compared to forest. The larger (up to 4 times) fraction of organic P (Po) than inorganic P (Pi) implies that total P is regulated by organic P. Easily-available P fractions (microbial biomass P, $NaHCO_3$-Pi and Po), moderately available P (NaOH-Po) and non-available P (HCl-Pi and Po) were much higher in organic farming than conventional farming and forest, especially at the 0–10 cm depth. Compared to organic farming, the higher (> 100) C_{org}: Po ratio that soils under conventional farming and forest are P limited which correspond with higher (2–8 times) activity of acid phosphatase in conventional farming and forest. Concluding, land use and management practices i.e. crop rotation, residue input and farmyard manure application significantly increase different fractions of P in organic farming.

1. Introduction

Land-use change, such as conversion of forest to intensively managed agriculture, is the largest global change of the last two centuries due to the increasing demands of feeding the growing human population [1]. During the period of 1980–2000, approximately 50% of the new arable land came from intact forest, while 28% came from disturbed forest in the tropics [2]. Furthermore, land-use change significantly alters the physical, chemical and biological properties of soil, affecting soil fertility and ultimately reducing the capacity of land for sustainable crop production [3].

Land-use change has substantial effects on phosphorus (P) availability for plant uptake by increasing P losses or P transfer into recalcitrant pools, leading to significant alterations in P distribution and availability [4]. The main sources of soil P are either parent material or application of mineral and/or organic fertilizers [5]. Other than N, P is considered as the largest globally limiting nutrient for food production [6]. P availability may be limited due to 1) inherent characteristics of the parent material 2) strong sorption of PO_4^{3-} to Al and Fe (hydro) oxides or 3) a low input of inorganic and organic fertilizers [7]. Plants and microorganisms have developed a broad range of mechanisms to enhance the acquisition of P, e.g., production of phosphatase enzymes, which are responsible for hydrolyzing recalcitrant forms of organic P to make it available to plants [8]. Plants can only produce acid phosphatases whereas microbes have capacity to produce both acid and alkaline phosphatases [9]. Microorganisms play a vital role in P mineralization from various organic sources [10] and transformations of soil organic P [11]. Thus, soil microorganisms are a key pool not only of C and N, but also of P. Furthermore, a majority of the P held in microorganisms can be released quickly and be readily available for plant growth [12]. The activity of phosphatase is negatively correlated with availability of inorganic P [13]. Previous studies have examined the effects of land-use change on P forms, distribution along soil depth, availability for plants and long term stability as a consequence of forest conversion to monoculture plantations [4] mineral and manure fertilization [14], tillage system [15] and cropping/vegetation systems

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